Award Number: W81XWH-11-2-0020

TITLE: USASOC Injury Prevention/Performance Optimization Musculoskeletal Screening Initiative

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REPORT DATE: November 2011

TYPE OF REPORT: Annual

PREPARED FOR: U.S. Army Medical Research and Materiel Command
Fort Detrick, Maryland 21702-5012

REPORT DOCUMENTATION PAGE

Form Approved
OMB No. 0704-0188

1. REPORT DATE *(DD-MM-YYYY)*	**2. REPORT TYPE**	**3. DATES COVERED** *(From - To)*

4. TITLE AND SUBTITLE	**5a. CONTRACT NUMBER**
	5b. GRANT NUMBER
	5c. PROGRAM ELEMENT NUMBER
6. AUTHOR(S) E-Mail:	**5d. PROJECT NUMBER**
	5e. TASK NUMBER
	5f. WORK UNIT NUMBER
7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES)	**8. PERFORMING ORGANIZATION REPORT NUMBER**
9. SPONSORING / MONITORING AGENCY NAME(S) AND ADDRESS(ES) U.S. Army Medical Research and Materiel Command Fort Detrick, Maryland 21702-5012	**10. SPONSOR/MONITOR'S ACRONYM(S)**
	11. SPONSOR/MONITOR'S REPORT NUMBER(S)

12. DISTRIBUTION / AVAILABILITY STATEMENT
Approved for Public Release; Distribution Unlimited

13. SUPPLEMENTARY NOTES

14. ABSTRACT

15. SUBJECT TERMS

16. SECURITY CLASSIFICATION OF:			**17. LIMITATION OF ABSTRACT**	**18. NUMBER OF PAGES**	**19a. NAME OF RESPONSIBLE PERSON**
a. REPORT	**b. ABSTRACT**	**c. THIS PAGE**			USAMRMC
U	U	U	UU		**19b. TELEPHONE NUMBER** *(include area code)*

Standard Form 298 (Rev. 8-98)
Prescribed by ANSI Std. Z39.18

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INTRODUCTION

Unintentional musculoskeletal injuries limit tactical readiness, shorten the active duty life cycle, and diminish the quality of life of the soldier after military service. Many of these injuries are preventable or their severity mitigated through implementation of demand-specific physical training for injury prevention and performance optimization developed through scientific research. At the request of the Command Surgeon from the United States Army Special Operations Command (USASOC), this research proposal will support development of USASOC's Tactical Human Optimization, Rapid Rehabilitation, and Reconditioning (THOR3) program to identify the priorities necessary for enhancement and change in the current physical training program. Consistent with our injury prevention and performance optimization model previously developed from over 20 years of research with elite athletes and six years of collective research with Naval Special Warfare Group 2 (NSWG2) and the 101st Airborne (Air Assault), this proposal will address the cause and prevention of musculoskeletal injury and detriments to optimal performance by identifying suboptimal biomechanical, musculoskeletal, physiological, and nutritional characteristics that are task and demand-specific to the Special Forces soldier.

BODY

Project Overview

This collaborative research proposal was modeled after our research with Naval Special Warfare and was submitted to program announcement W81XWH-09-DMRDP-ARATDA at the request of the Command Surgeon of the United States Army Special Operations Command (USASOC) to support development of USASOC's Tactical Human Optimization, Rapid Rehabilitation, and Reconditioning (THOR3) program and identify the priorities necessary for improvement and change in their current physical training program. The overall objective of our four phase research is to provide the scientific arm by which USASOC will refine its THOR3 program. It is our intent the research will result in a validated THOR3 program that reduces unintentional musculoskeletal injury and improves physical and tactical readiness. The current research proposal under this award will test the first three phases of research and is hypothesized to result in identified injury characteristics and risk factors of the USASOC Operator and a validated THOR3 program which alters injury risk characteristics. The proposed research study addresses the project/tasks as outlined in Funding Opportunity Number: W81XWH-09-DMRDP-ARATDA (Operational Health and Performance- Fundamental Mechanisms of Training and Operational Injury). The fourth and final phase of research will test the THOR3 program to reduce unintentional musculoskeletal injury (not part of the current submission- to be submitted under a separate SOW).

The current proposal will include activities performed at the USASOC/University of Pittsburgh Human Performance Research Laboratory at Fort Bragg, NC and protocol development, research monitoring, verification of data integrity, report preparation, and data processing/interpretation completed at the Neuromuscular Research Laboratory, University of Pittsburgh, Pittsburgh, PA.

Specific Aims:

Phase 1 Aim 1: To perform an epidemiological analysis of the unintentional musculoskeletal injuries sustained by USASOC Operators

Methods: A descriptive epidemiological design will be used to analyze retrospective unintentional musculoskeletal injury data from the previous five years of operation. Injury data will be queried from the Armed Forces Health Surveillance Center (AFHSC) and medical records maintained by the medical and physical therapy personnel of USASOC. Injury data from the AFHSC will be queried based on ICD-9 codes 710-739 and 800-899 and when available supplemented with ICD-9 E codes (external causes of injury codes). Individual encounters will be reported based on the ICD-9/ICD-9 E codes for a given anatomic region, limb, and identified with the corresponding time category for date range. Encounters will be defined as one injury per anatomic region every 60 days. Demographic data including age, height, and weight will be reported. Injury data queried by the medical and physical therapy personnel of USASOC will provide a summary of injury mechanisms to supplement the ICD-9 E codes. Phase 1 Aim 1 research activities will be performed in Y1Q1-Y1Q2.

Deliverables: The data from this aim will measure the frequency of unintentional musculoskeletal injury sustained by the USASOC Operator. The data from this aim will also be used to modify laboratory testing in Phase 2 should group-specific injury patterns be identified. This specific aim will also be used to identify the necessary procedures for injury data collection in Phase 4. The data from this aim will be submitted for publication with authors from the University of Pittsburgh and Command Surgeon of the US Army Special Operations Command. The authors submit the paper with the understanding that the manuscript has been read and approved by all authors and that all authors agree to the submission of the manuscript to the peer-reviewed journal. All named authors must have made an active contribution to the conception and design and/or analysis and interpretation of the data and/or the drafting of the paper and all must have critically reviewed its content and have approved the final version submitted for publication.

Phase 1 Aim 2: To describe the tactical and physical tasks which result in the greatest proportion of unintentional musculoskeletal injuries

Methods: Based on the injury data and in consultation with USASOC personnel (training, medical, human performance, and Team Sergeants) representative tactical tasks will be identified to quantify segmental accelerations of the spine and lower extremity and describe the biomechanical and musculoskeletal demands. Collaboration with USASOC personnel will identify the mission-specific tasks which result in unintentional musculoskeletal injury. Data will be examined on a sample of Operators based on the identified tactical tasks. Injury data from the medical and physical therapy personnel of USASOC will support identification of appropriate tasks which result in significant injury to the USASOC Operator.

Deliverables: The data from this aim will be used to supplement the injury data identified in Phase 1 Aim 1 to further describe the injuries sustained by the USASOC Operators. The data from this aim will also be used to develop functional laboratory tests to replicate USASOC-specific demands. This specific aim will also be used to identify the necessary procedures for injury data collection in Phase 4. The data from this aim will be submitted for publication with authors from the University of Pittsburgh and Command Surgeon of the US Army Special Operations Command. The authors submit the paper with the understanding that the manuscript has been read and approved by all authors and that all authors agree to the submission of the manuscript to the peer-reviewed journal. All named authors must have made an active contribution to the conception and design and/or analysis and interpretation of the data and/or the drafting of the paper and all must have critically reviewed its content and have approved the final version submitted for publication.

Phase 2 Aim 1: To prospectively identify biomechanical, musculoskeletal, physiological, and nutritional risk factors for injury in USASOC Operators

Methods: A prospective analysis of risk factors for unintentional musculoskeletal injury will be conducted based on biomechanical, musculoskeletal, and physiological data collection. The biomechanical characteristics of the knee, shoulder, and torso will be analyzed using a 3D motion analysis and force plate system. Isokinetic and isometric strength of the neck, torso, shoulder, knee, hip, and ankle will be measured with an isokinetic device or handheld dynamometer. Range of motion of the neck, torso, shoulder, knee, hip, and ankle will be assessed with goniometers. Static and dynamic balance will be assessed with force plates and a stability system. Body composition will be measured with air displacement plethysmography. Aerobic capacity and lactate threshold will be measured with a metabolic system and lactate analyzer. Anaerobic power and capacity will be measured with an electromagnetic ergometer. Nutrition data will include a 24 hour recall and nutrition history. The 24 hour recall will be assessed with the ASA 24 to assess food types and quantities. A nutrition history will assess supplement intake, overall habits, and fueling and hydration habits before, during, and after physical training. These data will be analyzed in relation to prospectively collected unintentional musculoskeletal injury data (self-reported, AFHSC, medical and physical therapist-reported). Injury data will be captured for the 12 month period following laboratory testing. It is our intent that utilizing several sources of injury data will improve the validity of the data query for completeness without relying solely on an individual source where potential injuries, mechanisms, or tasks may be empty. Based on a cumulative incidence of 13-22%

injured for given musculoskeletal injuries up to 480 subjects will be required to identify biomechanical, musculoskeletal, and physiological contributors to injury with a power of 0.80 and statistical power of $p < 0.05$. Phase 2 Aim 1 research activities will be performed Y1Q3-Y3Q4.

Deliverables: The data from this phase will prospectively identify risk factors for unintentional musculoskeletal injury. The data may be used as a screening mechanism to identify individual Operators who may be at a greater risk of injury due to established risk factors. This data will be provided to USASOC's THOR3 human performance personnel to integrate into current physical training for validation in Phase 3. Specific recommendations will be made for changes in the THOR3 program based upon the data obtained. The data from this aim are the foundation by which the THOR3 program will be implemented in Phase 4. The data from this aim will be submitted for publication with authors from the University of Pittsburgh and Command Surgeon of the US Army Special Operations Command. The authors submit the paper with the understanding that the manuscript has been read and approved by all authors and that all authors agree to the submission of the manuscript to the peer-reviewed journal. All named authors must have made an active contribution to the conception and design and/or analysis and interpretation of the data and/or the drafting of the paper and all must have critically reviewed its content and have approved the final version submitted for publication.

Phase 2 Aim 2: To determine the relationship between previous history of unintentional musculoskeletal injury and biomechanical, musculoskeletal, physiological, and tactical characteristics

Methods: Biomechanical, musculoskeletal, physiological data captured during Phase 2 Aim 1 and tactical characteristics will be evaluated to determine the relationship with retrospective unintentional musculoskeletal injury history. Unintentional musculoskeletal injury data will be captured with a self-reported questionnaire to identify the frequency of injury, mechanisms, tasks, and other contributing factors of the injury event. Phase 2 Aim 2 research activities will be performed Y1Q3-Y3Q4.

Deliverables: The data from this aim will identify potential residual deficits as a function of previous injury and impact as confounding factors to laboratory testing. The data from this aim are the foundation by which the THOR3 program will be implemented in Phase 4. The data from this aim will be submitted for publication with authors from the University of Pittsburgh and Command Surgeon of the US Army Special Operations Command. The authors submit the paper with the understanding that the manuscript has been read and approved by all authors and that all authors agree to the submission of the manuscript to the peer-reviewed journal. All named authors must have made an active contribution to the conception and design and/or analysis and interpretation of the data and/or the drafting of the paper and all must have critically reviewed its content and have approved the final version submitted for publication.

Phase 2 Aim 3: To identify suboptimal biomechanical, musculoskeletal, physiological, tactical, and nutritional characteristics for physical readiness in the USASOC Operator

Methods: Biomechanical, musculoskeletal, physiological, and tactical readiness data captured in Phase 2 Aim 2 will be analyzed for suboptimal contributors to physical readiness. Biomechanical, musculoskeletal, physiological, and nutrition data will be compared to data sets of athletes, evidenced-based practice, and tactical athletes when appropriate. These data sets will include athletes tested at the Neuromuscular Research Laboratory at the University of Pittsburgh, literature demonstrating risk factors for unintentional musculoskeletal injury, characteristics of suboptimal performance, and data from tactical athletes from other University of Pittsburgh US Special Operations Command research projects. This comprehensive approach will be utilized to identify specific suboptimal characteristics relative to performance optimization without relying solely on an individual source for comparison. An additional USASOC tactical athlete cohort from the current study will be included once sufficient data are obtained to primarily test the tactical readiness characteristics. Phase 2 Aim 3 research activities will be performed Y1Q3-Y3Q1.

Deliverables: The data from this aim will establish suboptimal physical readiness characteristics based on comparison to athlete, evidence-based, and tactical athlete optimization data sets. The data will be

provided to USASOC's THOR3 human performance personnel to integrate into current physical training for testing in Phase 3 and Phase 4 (not part of the current submission- to be submitted under a separate SOW). The nutrition data will be provided to the THOR3 registered dietitian for immediate implementation into clinical practice and not further tested with Phase 3 or 4. The data from this aim will be submitted for publication with authors from the University of Pittsburgh and Command Surgeon of the US Army Special Operations Command. The authors submit the paper with the understanding that the manuscript has been read and approved by all authors and that all authors agree to the submission of the manuscript to the peer-reviewed journal. All named authors must have made an active contribution to the conception and design and/or analysis and interpretation of the data and/or the drafting of the paper and all must have critically reviewed its content and have approved the final version submitted for publication.

Phase 3: To validate THOR3's human performance program to modify injury mitigating and human performance characteristics identified in Phase 2

Methods: Upon receipt of the Phase 1 and Phase 2 results, USASOC's THOR3 human performance personnel will evaluate the biomechanical, musculoskeletal, physiological, tactical, and injury data and refine its current human performance program to address the injury mitigating and human performance characteristics. A randomized controlled clinical trial intervention design will be implemented with USASOC Operator units assigned to either an experimental (revised THOR3 training) or control (current THOR3 training) group as part of the intervention. Pre- and post-testing of biomechanical, musculoskeletal, physiological, and tactical characteristics will be performed as outlined in Phase 2. THOR3's revised human performance program will be tested in a 12 week intervention and instructed by THOR3 human performance personnel as part of their daily training of the Operators. Based on several individual power analyses performed for the dependent variables (biomechanical, musculoskeletal, physiological) to be assessed during this aim, quadriceps strength data yielded the most conservative estimate and was selected to calculate the sample size. Previously collected data (Quadriceps Strength Mean: 271.7 ± 59.3) and an expected effect size improvement of 0.69 following the intervention indicated a total of 150 subjects will be needed to achieve a power of 0.80 with a probability of $p < 0.05$. A total of 200 subjects will be recruited to account for attrition. Phase 3 research activities will be performed Y3Q2-Y3Q4.

Deliverables: The data from this aim will test the effectiveness of the revised THOR3 program to modify the identified biomechanical, musculoskeletal, physiological, and tactical characteristics that predict injury, physical readiness, and tactical performance. Based upon the results of this aim, the THOR3 program may be augmented to address insufficient findings prior to formal implementation into USASOC Operator training and testing for injury mitigation in Phase 4. The data from this aim will be submitted for publication with authors from the University of Pittsburgh and Command Surgeon of the US Army Special Operations Command. The authors submit the paper with the understanding that the manuscript has been read and approved by all authors and that all authors agree to the submission of the manuscript to the peer-reviewed journal. All named authors must have made an active contribution to the conception and design and/or analysis and interpretation of the data and/or the drafting of the paper and all must have critically reviewed its content and have approved the final version submitted for publication.

Overall Deliverables and Way Forward: Phase 4 of the research (not part of the current submission- to be submitted under a separate SOW) will test the effectiveness of the THOR3 program to mitigate unintentional musculoskeletal injuries with a larger prospective study. Injury data will be evaluated pre- and post-implementation of the revised THOR3 program and between like tactical units. This phase of research will incorporate subjects from across USASOC and evaluate stratified data based on tactical requirements.

KEY RESEARCH ACCOMPLISHMENTS

- Finalized statement of work and research aims
- Completed IRB submissions
- Laboratory construction ongoing
- Data collection to begin Q1 2012

REPORTABLE OUTCOMES

Abstracts
Not applicable

Manuscripts
Not applicable

Grant Submissions
Not applicable

CONCLUSIONS
None- data collection to begin Q1 2012

REFERENCES
Not applicable

APPENDICES
Not applicable

SUPPORTING DATA
Not applicable